Presentation at the Aspen Meeting of the PAC

John Womersley

On behalf of the DØ Collaboration

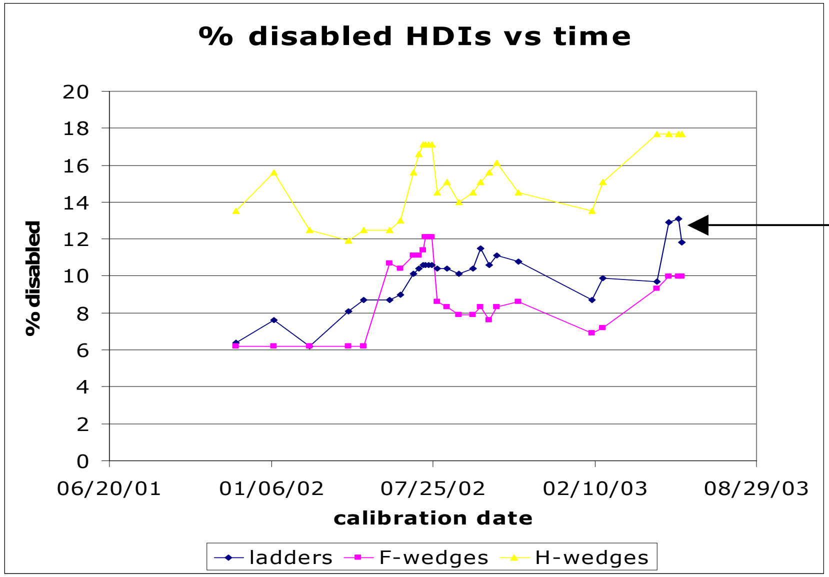
June 2003

Question 1

What is currently your best understanding of how the performance of the silicon detector will diminish with increasing integrated luminosity? What is the impact of this degradation in performance on the most important physics analyses? Which physics topics suffer the most from this effect and which least?

- **Radiation damage lifetime estimated from**
  - **locations and types of detectors installed in DØ**
  - **measurement-based knowledge of the phenomenology of radiation damage**
  - **actual measured doses received**
  - **expect the lifetime will be limited by micro-discharge breakdown of the junction in the Micron detectors in the inner barrels.**
    - **begins to occur at bias of ~ 150 V; all channels fail at ~200 V**
  - **will start to lose significant numbers of channels at an integrated luminosity of 3.6 ± 1.8 fb^{-1}**
  - **all of the channels on the inner layer will be dead by 4.9 ± 2.5 fb^{-1}.**
    - **These uncertainties reflect how well we can estimate the micro-discharge formation and dose accumulation.**

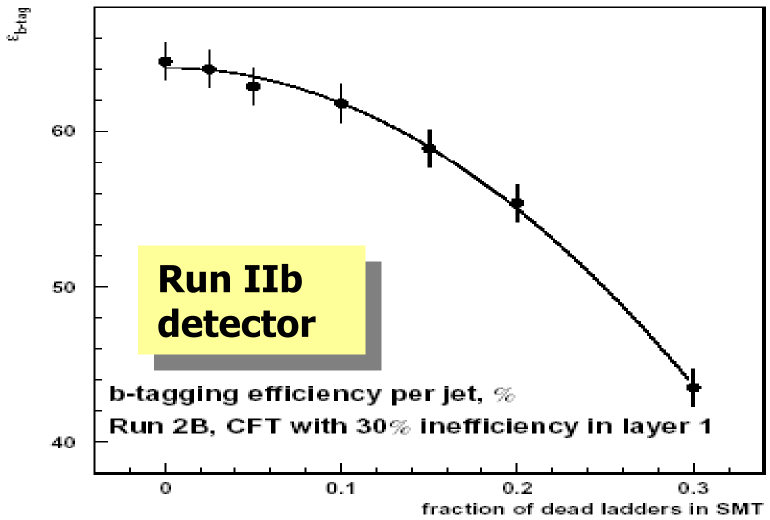
- **Longevity of the detector**
  - Fraction of disabled ladders was 6% in 2001 and is ~ 12% now
  - No reason to believe this is anything to do with radiation damage
  - We have no idea how to extrapolate this to the future



% ladders disabled

Impact of degradation

- **We know that loss of silicon layers will impact b-tagging:**



  - **Lower efficiencies**

- **Also degrades precise tracking and primary vertex identification capability**
  - **Hence worse missing E_T and jet resolution**

Physics affected

- **Physics which requires multiple b-tags is affected most:**
  - **Top quark physics, including precision mass measurements**
  - **Standard Model Higgs Searches**
  - **Supersymmetry searches involving light stop and sbottom**
  - **Supersymmetry searches involving cascade decays of squarks or gluinos to heavy flavor**
  - **Supersymmetric Higgs searches in 4b and bb$\tau\tau$ modes**
  - **Technicolor searches**
  - **The entire B-physics program**
    - **Flagship physics of the Tevatron**

- The silicon detector is an integral part of the DØ tracking system
  - Needed for pattern recognition and track sagitta measurements
- Almost all physics is affected by loss of precision tracking and primary vertex identification:
  - W mass and electroweak physics
  - Supersymmetry searches in trileptons
  - Supersymmetry searches with taus
  - Extra dimensions
  - Jets and missing E_T

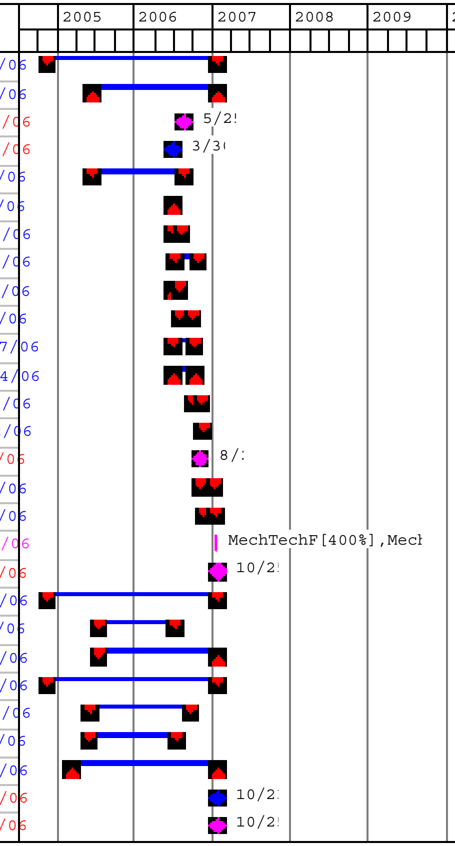
Question 2

How much time is needed to install and commission the new silicon detectors?

- **We have put together a fully resource loaded plan for**
  - **Opening the detector**
  - **Removal of the old silicon**
  - **Installation of the new silicon**
    - **4.5 months**
  - **Cabling and Technical commissioning**
    - **10 weeks (1.5 shifts, 2 teams of 2 people per shift)**
  - **Online software (downloads, calibrations, unpacking, monitoring…)**
    - **1.5 months (in parallel with above)**

Run IIb Installation (Silicon, L1, L2 Triggers)

ID	WBS	Task Name	Duration	Start	Finish
1	1.5	Run IIb Installation	109.6 w	Thu 8/12/04	Wed 10/25/06
2	1.5.1	Run IIb Silicon Installation	81.4 w	Mon 3/14/05	Wed 10/25/06
3	1.5.1.1	Silicon Ready To Move To DAB	0 w	Thu 5/25/06	Thu 5/25/06
4	1.5.1.2	Shutdown for Installation Begins	0 w	Thu 3/30/06	Thu 3/30/06
5	1.5.1.3	Prepare Silicon Infrastructure	60 w	Mon 3/14/05	Wed 5/24/06
23	1.5.1.4	Open Detector and Install CC-EC Scaffolding	0.8 w	Thu 3/30/06	Wed 4/5/06
29	1.5.1.5	Uncable Silicon, Remove LVPS and IB Crates	5 w	Wed 4/5/06	Tue 5/9/06
38	1.5.1.6	Modify RunIIa Interface Boards, Test, Reinstall	15.8 w	Thu 4/6/06	Thu 7/27/06
47	1.5.1.7	Remove RunIIa Silicon	4.2 w	Wed 4/5/06	Thu 5/4/06
58	1.5.1.8	Install RunIIb Silicon Detector	7.4 w	Thu 5/4/06	Mon 6/26/06
68	1.5.1.9	Install New HV System	14 w	Thu 3/30/06	Fri 7/7/06
75	1.5.1.10	Install New LV System	15 w	Thu 3/30/06	Fri 7/14/06
81	1.5.1.11	Cable RunIIb Silicon	6 w	Tue 6/27/06	Tue 8/8/06
85	1.5.1.12	Install Run IIb Beryllium Beam Tube	2 w	Wed 8/9/06	Tue 8/22/06
89	1.5.1.13	Ready To Begin Technical Commissioning	0 w	Wed 8/2/06	Wed 8/2/06
90	1.5.1.14	Technical commissioning of detector	10 w	Wed 8/2/06	Wed 10/11/06
95	1.5.1.15	Commission Online Readout Software	8 w	Wed 8/23/06	Wed 10/18/06
101	1.5.1.16	Close calorimeter and muon system	2 w	Thu 10/12/06	Wed 10/25/06
102	1.5.1.17	Silicon System Ready for Beam	0 w	Wed 10/25/06	Wed 10/25/06
103	1.5.2	Run IIb Trigger Installation	109.2 w	Thu 8/12/04	Mon 10/23/06
104	1.5.2.1	Prepare Infrastructure at DAB	49 w	Mon 4/11/05	Wed 4/5/06
114	1.5.2.2	Level 1 Calorimeter Trigger	77 w	Mon 4/11/05	Mon 10/23/06
124	1.5.2.3	Level 1 Calorimeter Track Matching	109.2 w	Thu 8/12/04	Mon 10/23/06
134	1.5.2.4	Level 1 Tracking	64.4 w	Thu 3/10/05	Thu 6/22/06
153	1.5.2.5	Level 2 Beta Processors	57 w	Mon 2/28/05	Wed 4/19/06
166	1.5.2.6	Silicon Track Trigger Upgrade	93 w	Wed 12/8/04	Mon 10/23/06
181	1.5.2.7	Trigger Upgrade Ready for Beam	0 w	Mon 10/23/06	Mon 10/23/06
182	1.5.3	Run IIb Detector Ready for Beam	0 w	Wed 10/25/06	Wed 10/25/06



- **The plan also integrates the installation of the trigger upgrades**
- **Total shutdown duration is 7 months**
  - **Experts feel this is conservative**

Question 3

At what time after the end of the shutdown period would the full experiment be able to record physics-quality data with good efficiency?

- **We know we have to come up quickly**
- **We are putting a detailed beam commissioning plan together**

- **Silicon**
  - **In Run II we had problems with**
    - **LV power supplies – now moved outside the hall**
    - **Downstream electronics – now fixed, will not change**
    - **Interface boards – hence heavy emphasis on technical commissioning before close-up**
  - **Successful as-built alignment procedure allowed physics quality data to be taken rapidly in Run IIa**

- **Trigger**
  - **Will use splitter cards to allow parasitic commissioning of calorimeter trigger before the long shutdown**
  - **Calorimeter trigger calibration requires ~ 1 week of beam time + 4 weeks analysis after shutdown**

- **For the silicon and trigger upgrades together, we estimate that 3 months of commissioning time with beam will be needed**

Question 4

What strategy would the collaboration prefer for the detector upgrades and what are the most important drivers of this position? What should be the conditions for beginning the extended shutdown to install the silicon detector upgrades? What is the minimum time of operation after the shutdown needed to justify installing the silicon detector?

- **I shall defer answering the first part until the end of this presentation**

Conditions to begin shutdown

- We cannot state hard-and-fast conditions for beginning the silicon installation shutdown.
- The decision will be a complicated optimization exercise including a good measure of gut feeling.
- We will need to consider:
  - The state of readiness of the detector upgrades (both DØ and CDF)
  - The performance of the existing tracking system including
    - radiation damage (if any)
    - further component losses (if any)
    - pattern recognition performance in the high occupancy environment
  - Accelerator performance up to that date and projections for the following two years
  - The state of the LHC accelerator and detectors at that time
  - Any discoveries or hints of new physics in the Run II data.

How long to run?

- It is important to note that the upgraded DØ silicon detector offers increased performance over the current device.
  - six layers rather than four
    - better pattern recognition at high occupancy
  - inner layers are closer to the beampipe
    - Significantly improved b-tagging
  - It is not a spare part, it is a higher performance detector.
  - A very rough figure of merit is that the double b-tagging efficiency with the new detector is 1.7 times higher than the existing device, even in the absence of radiation damage to the latter
    - Full GEANT simulation of ZH + 7.5 minbias events

- We believe that, after roughly a year of downtime, a physics running period also of a year or so at high luminosity would justify installing the new detector.

Question 5

Please review the motivation for each of the non-silicon detector upgrades and comment on any substantial changes that might occur due to the new luminosity profiles.

- **For DO, the non-silicon upgrades are:**
  - **Level 1 trigger**
    - **Calorimeter clustering at level 1**
    - **Calorimeter-track matching**
    - **Fiber tracker trigger upgrade**
  - **Level 2 trigger**
    - **Silicon Track Trigger upgrade**
    - **Beta processors**
  - **Level 3**
    - **Processor upgrades**

- **These upgrades were designed to handle luminosity of 2×10^{32} cm^{-2}s^{-1} with a bunch spacing of 396 ns, maintaining enough headroom to handle peak luminosities up to 4×10^{32} cm^{-2}s^{-1}.**
  - **The motivation is to keep the L1 accept rate under control and to maintain rejection at L2 and L3**

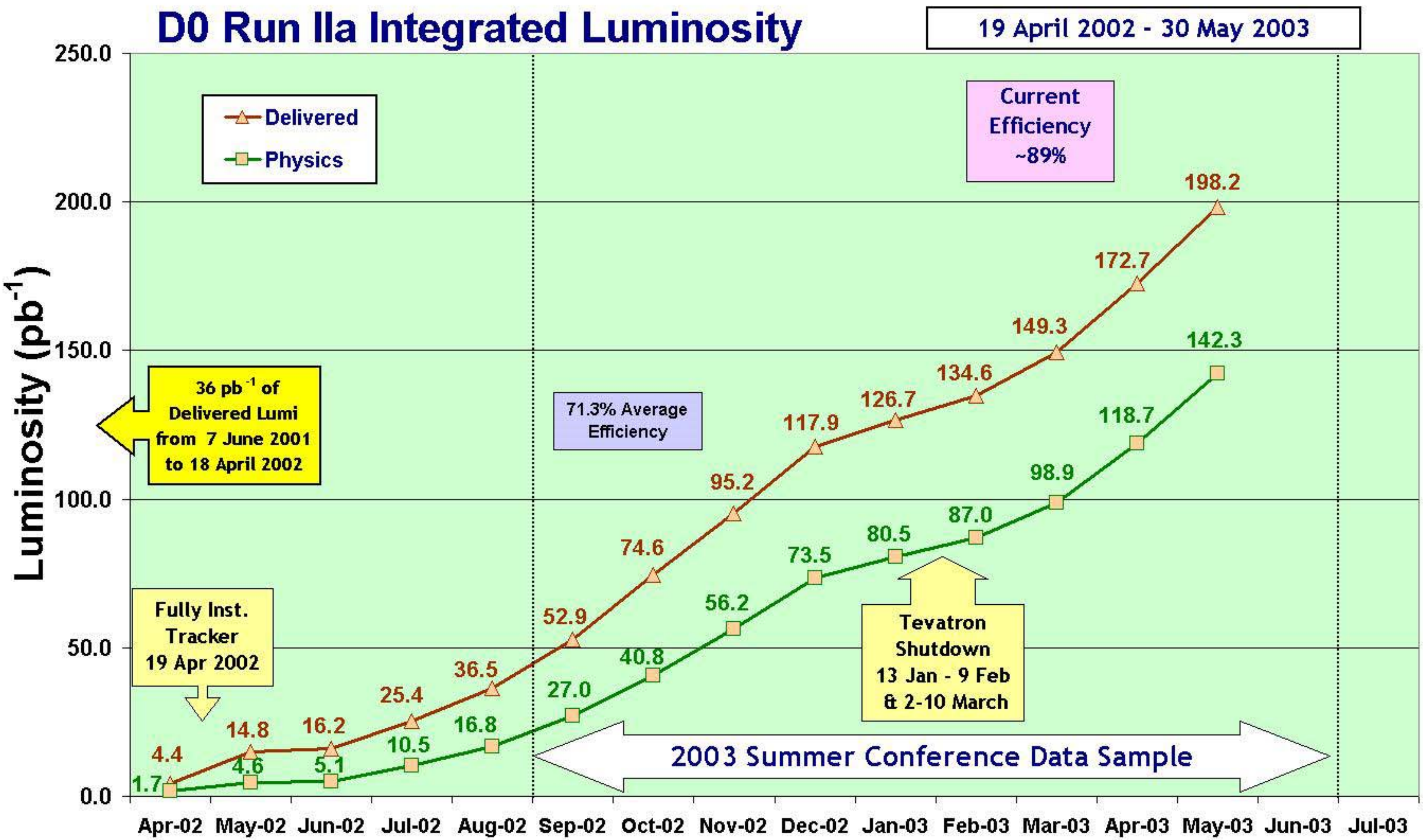
- **The upper curve of the new luminosity profile corresponds to instantaneous luminosity reaching 2×10^{32} cm^{-2}s^{-1} some time in FY06, and approaching 3×10^{32} cm^{-2}s^{-1} in FY08.**

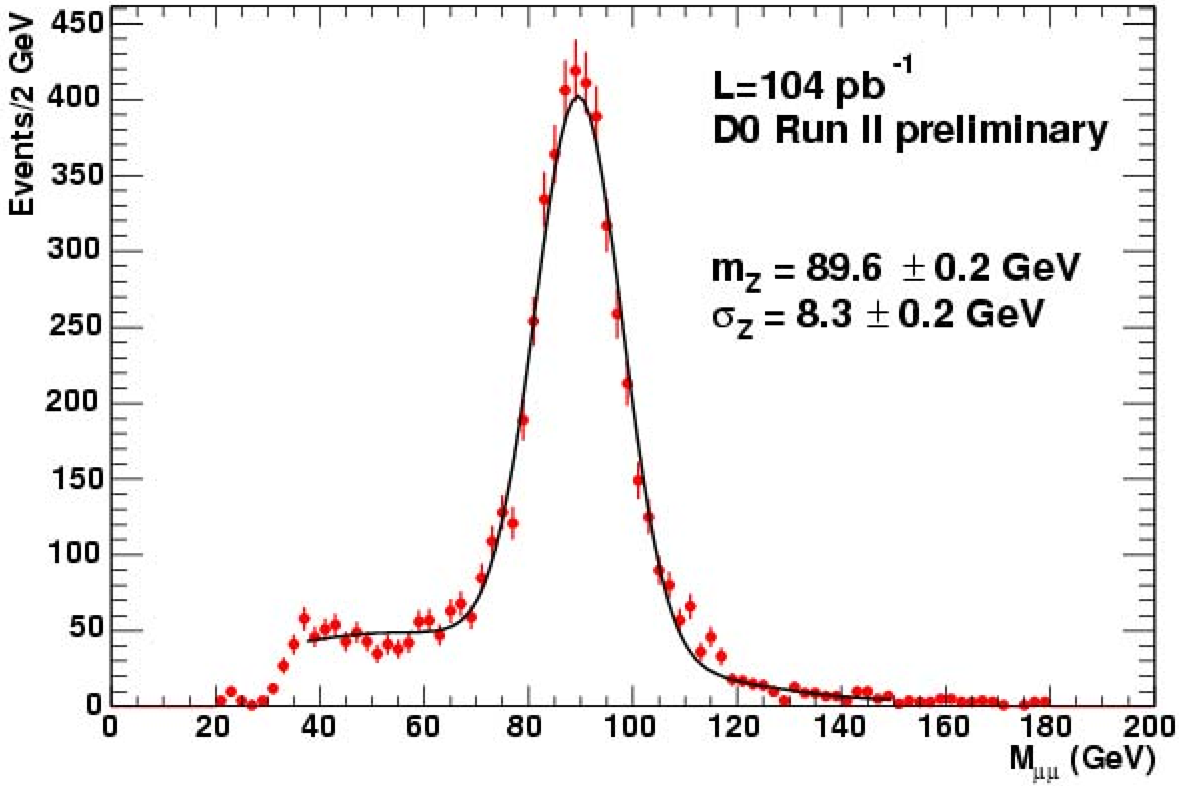
- **The lower curve exceeds 1×10^{32}cm^{-2}s^{-1} in FY07, and eventually reaches about 1.7×10^{32}cm^{-2}s^{-1}.**

All of the non-silicon upgrades are still required*

*** Part of the STT upgrade is still needed even without the silicon upgrade**

Ancillary Questions

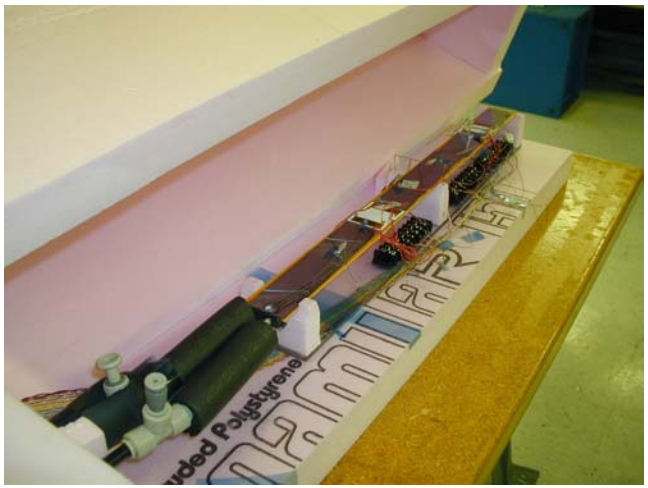

D0 Run IIa Integrated Luminosity
19 April 2002 - 30 May 2003
Delivered
Physics
Current Efficiency ~89%
36 pb-1 of Delivered Lumi from 7 June 2001 to 18 April 2002
71.3% Average Efficiency
Fully Inst. Tracker 19 Apr 2002
Tevatron Shutdown 13 Jan - 9 Feb & 2-10 March
2003 Summer Conference Data Sample
Luminosity (pb-1)
250.0
200.0
150.0
100.0
50.0
0.0
4.4
14.8
16.2
25.4
36.5
52.9
74.6
95.2
117.9
126.7
134.6
149.3
172.7
198.2
1.7
4.6
5.1
10.5
16.8
27.0
40.8
56.2
73.5
80.5
87.0
98.9
118.7
142.3
Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02 Jan-03 Feb-03 Mar-03 Apr-03 May-03 Jun-03 Jul-03

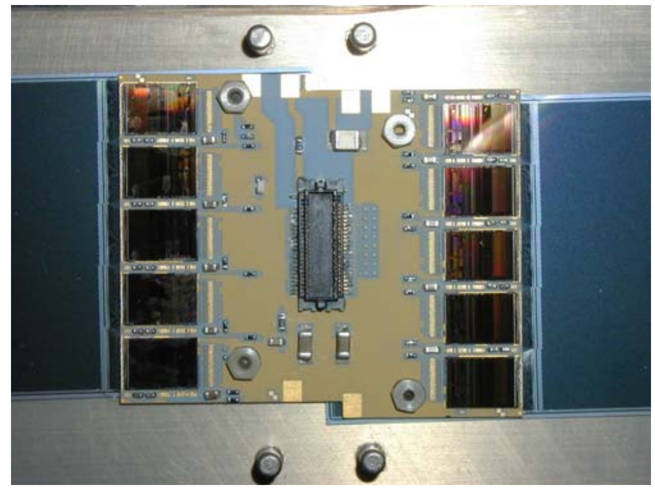


$Z \to \mu^+\mu^-$ with 104pb^{-1} of 2002-2003 data

Upgrade Status

- **The detector upgrades are proceeding well**
  - Latest version of the SVX4 chip looks good
  - We have prototyped all components





  - No major technical problems remain
  - We have started to place the final production orders for various components
  - Roughly $8M has been obligated so far of $28.6M TPC (45% cont)
    - $2.5M "in kind" including $2M from NSF
  - Available contingency can take us to roughly January 04

The collaboration

- We are continuing to add members
  - At next week's Institutional Board Meeting we will consider applications from Clermont-Ferrand and from Simon Fraser University
  - We have expressions of interest from two more institutions
- For the Upgrade Lehman Review, we obtained MOU's from 75 of 76 institutions
  - All are committed to Run IIb or are developing proposals for continued participation.
  - We have commitments of sufficient physicist effort for the Run IIb detector projects.
  - Summed person-years meet or exceed requirements extracted from the resource-loaded schedule for both silicon tracker and trigger/DAQ/Online projects.
- For the operations phase, we understand that we need to transition to a "LEP-like" mode of running
  - Preliminary estimate: we need ~ 80 FTE's to operate the experiment, its software and computing

Physics issues beyond the Higgs

One Experiment	2 fb^{-1}	5 fb^{-1}	10 fb^{-1}
# high p_T jets > 400 GeV	1300	3300	6600
Gluino mass	400 GeV	~ 450 GeV?	~ 500 GeV?
Trileptons $m_{1/2}$ reach tan β = 5, m_0 small tan β = 5, m_0 large tan β = 35, m_0 large	 $m_{1/2}$ ~ 220 GeV -- $m_{1/2}$ ~ 120 GeV	 $m_{1/2}$ ~ 235 GeV $m_{1/2}$ ~ 140 GeV $m_{1/2}$ ~ 145 GeV	 $m_{1/2}$ ~ 250 GeV $m_{1/2}$ ~ 160 GeV $m_{1/2}$ ~ 170 GeV
GMSB γγ + ME_T chargino mass	325 GeV	345 GeV	370 GeV
SUSY Higgs + bb reach in tan β for m_A = 150 GeV	tan β > 45	tan β > 35	tan β > 27
Topcolor Z′→ tt	mass < 580 GeV	640 GeV	720 GeV
Z′→ dijets	mass < 560 GeV	610 GeV	650 GeV
Z′→ dileptons	mass < 1 TeV	1.15 TeV	1.3 TeV

- **And don't forget SUSY searches/exclusion using the h**

One experiment	**2 fb^{-1}**	**5 fb^{-1}**	**10 fb^{-1}**
# top events $\geq$3 jets + 1b-tag $\geq$4 jets + 2b-tags	 1000 240	 2500 600	 5000 1200
Top mass: Lepton + jets Dileptons	 2.7 GeV 2.8 GeV	 2.2 GeV 2.2 GeV	 1.6 GeV 1.6 GeV
Single top cross section (s / t) $\lvert V_{tb}\rvert$ (s / t channel)	 21% / 12% 12% / 10%	 13% / 8% 8% / 9%	 9% / 5% 6% / 8%
Top spin ½ vs. Spin 0	2σ	3σ	4.5σ
Rare decays $t \rightarrow c\gamma$ $t \rightarrow cZ$	$< 7.5 \times 10^{-3}$ $< 4 \times 10^{-2}$	$< 3 \times 10^{-3}$ $< 1.5 \times 10^{-2}$	$< 1.5 \times 10^{-3}$ $< 7.5 \times 10^{-3}$
W mass: transverse mass W/Z ratio method	 27 MeV 44 MeV	 22 MeV 28 MeV	 19 MeV 20 MeV
W width (direct)	32 MeV	24 MeV	18 MeV
$\sin^2\theta_W^{eff}$ (from A_{FB})	0.0007	0.00042	0.00028

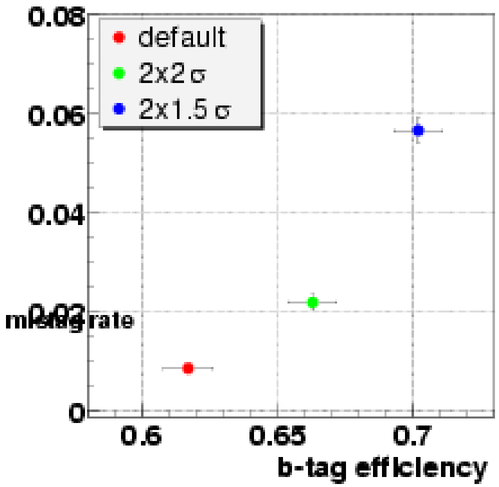
What counts for all of the above is luminosity × efficiency

Higgs sensitivity study

- CDF and DØ agreed to revisit the “famous” SM Higgs reach plot
  - CDF focus on WH channel
  - DØ focus on ZH channel
- No combined results yet
- What I have seen so far is rather encouraging
  - see next slide
- Goal is to show to Ray Orbach on June 24

M. Narain, A. Khanov, F. Rizatdinova

Loose vs tight *b*–tagging efficiency



HSGW: assumed 50% *b*–tagging efficiency.

We will have much higher even with tight *b*–tagging with run 2B upgrade.

Can also gain using loose *b*–tagging.

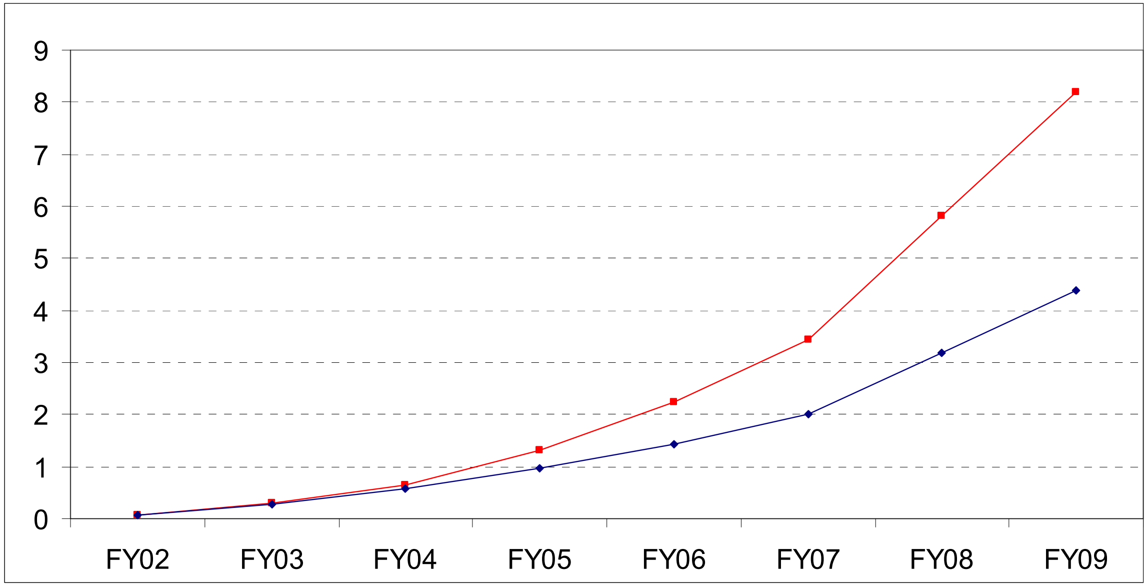
b-tagging studied with full GEANT simulation and pattern recognition

Question 4:

What strategy would the collaboration prefer?

Why are we here?

- Fermilab has submitted to DOE an accelerator plan



- There exists the implication that we should rethink the need for the Run IIb detector upgrades in light of this plan

What you expect me to say

- You might expect that I will stand up and say “we must still build the detector upgrades no matter what”

I am not going to do that

- I know at least some members of the community, and of this committee too, wonder whether upgrading makes sense
- I am not going to argue what the right thing to do will eventually turn out to be
- I am going to argue that now is not the time, and this is not the way, to reach such a conclusion
  - In fact “should we build the upgrades?” is not the right question to ask at all

The "spiral of death"

- Suppose we conclude something like this right now
  - "In light of the presented accelerator plan, and the high technical risk of achieving the upper goals, we feel it is no longer prudent to invest in the detector upgrades"
- The message we send is
  - "We do not really believe the accelerator luminosity upgrades will pay off. Maybe not at all (base profile), maybe not in time to be useful"
- Why would anyone continue to invest in such accelerator upgrades?
  - They won't.
  - What future does this leave for the collider?
- Why would anyone then invest in any new accelerator facility at Fermilab?
  - "After all, they can't make things work"
- Why would anyone then invest in any new accelerator facility in the USA, or want the USA as a technical partner?

We must not let this happen

Broader impact

- This is a big, visible, important question, not just for DØ or for Fermilab, but also for the future vitality of US accelerator-based HEP
- Potential loss of trust in our commitments, reliability and capabilities
  - International impact
- Potential loss of resources
  - One is starting to hear senior people saying semi-openly that they want to take resources away from Fermilab in light of the Run II outlook
    - I believe it is naïve to imagine that any such resources can simply be redirected
    - The perception of failure in a major HEP project will hurt us all
      - it certainly won't increase the likelihood of any other major HEP project being supported
    - Shooting inwards will hurt us all
      - How many times do we have to learn this lesson?
      - At this point we simply must help one another succeed.
- University groups have even been told that their CDF/DØ work is hard to support when the program "seems to be failing"

What do we have to do

- The real problem here is our accelerator performance and the level of credibility attached to our projections, planning, and management
- This is what must be addressed to get us out of the spiral
  - "Addressed" means dealing with both the perception – the public image of how we are doing – and the reality
  - Descoping our goals may be part of this process, but by itself does not constitute this process
  - If we do descope our goals we'd better be able to explain in a watertight way that it is because of unavoidable things like Maxwell's equations and maybe the old age of the machine (perhaps even insufficient funds?)
  - If human factors (our competence, management or lack-of-will) end up being blamed, then we are still in the spiral
  - Consider a stand-down from running the Tevatron, if necessary?
- How can we help?

The detector upgrades

- Sacrificing the upgrades now will do nothing to
  - Enhance the credibility of the accelerator plan
  - Restore confidence in Fermilab's ability to focus on and address problems
- If indeed it does end up being the right thing to do, then it has to be because
  - We are really and visibly getting our act together
  - And as part of that process, we (as a community) have in the end convinced ourselves that
    - there are unavoidable limitations to accelerator performance
    - an overall optimization of resources is appropriate
    - doing so will help secure the future of the field
  - None of these conditions is now true.
- It should not be done now, not in a rush because of a review, not this way, not based on this plan, and what little we know now.

Risk

- We always knew these upgrades were a gamble; we proceeded because the physics payoff was so significant.
  - It still is.
- Investors will tell you that if you want to make real money, you have to be prepared to make risky investments.

What we advocate

- We wish to see a wholehearted effort to get the most physics out of the Tevatron — a broad program — while it remains a unique facility in the world.
- This means that we should not back down from ambitious luminosity goals, but should work to put them on a firmer basis with a robust effort to address the technical and human issues that currently call them into question.
- The schedule is such that we cannot ask the detector upgrades to take a holiday while this happens. We have to keep going full pace.
- We should plan for success in the accelerator and we should not do anything that precludes taking full advantage of that success.
- We should proceed with the upgrades while we get our arms round the accelerator situation

We have to be sure we get this right, for the future of Fermilab and for the field as a whole…